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STRUCTURAL DIAGRAM OF AUTOMATED QUALITY CONTROL PROCESS OF SILICON WAFERS DURING THEIR SURFACE SHAPING

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Introduction. Currently the task of finding alternative energy sources is one of the most urgent tasks not only in Ukraine, but throughout the world. In Ukraine several types of energy production from renewable sources are used, but recently, special attention is paid to solar power plants. Monocrystalline and polycrystalline silicon wafers for solar panels are used as solar cells. As solar cells for solar panels the monocrystalline and polycrystalline silicon wafers are used.

In manufacturing process the semiconductor wafers go through a long technological route (Fig.1).

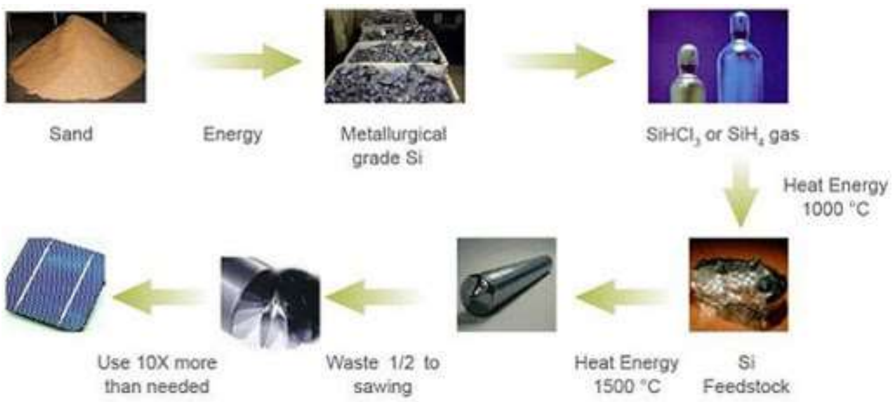

Figure 1. Stages of solar cell manufacturing

The first stage consists in crystals growing. They are fabricated from quartz sand with a high silicon concentration. First, the sand is melted at high temperatures (up to 1000-2000 °*C*), then cleaned up and synthesized. The result of these operations is doped silicon for growing monocrystalline or polycrystalline wafers.

The crystals are fabricated using the technology of gradual cooling of a silicon wafer, which is less expensive, because of this the polycrystalline modules are cheaper in comparison with monocrystalline wafers.

Main part. After growing, the formed crystals are transmitted for processing. At this stage, they are given the required shape and cut into wafers with a thickness of 250-300 μm.

At this stage, it is very important to carry out in-line surface quality control, since the technology of semiconductor wafers shaping and processing affects solar panel energy efficiency. The existing technologies for the polycrystalline wafers manufacture have a significant drawback, which is that silicon has areas with granular boundaries, which are worse its quality. After the wafer abrasive processing (grinding), some microcracks are left on its surface (Fig.2).

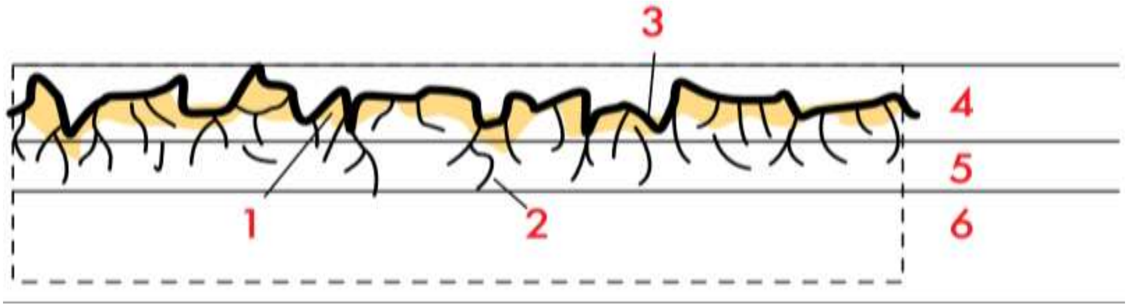

Figure 2. Cross-sectional view of the grinded off silicon wafer

The next areas are marked with numbers in the Fig.2: 1 is inelastic deformation zone; 2 are microcracks; 3 is surface after grinding; 4 is relief layer (0.5-1.0 μm); 5 is near-surface layer (1.0-2.0 μm) and 6 is base wafer material.

To increase the efficiency of the charged particles generation on solar panel, it is necessary to reduce the silicon crystal surface roughness, as well as to improve the testing operation and the control process of the shaping of the polycrystalline wafers surface.

For mechanical processing of silicon, conventional turning, milling, planing and drilling machines cannot be used. This is explained by the fact of high fragility of semiconductor materials. Therefore, a main method for their mechanical processing is the processing by abrasives in a bound state (diamond discs) and in a free state (abrasive suspensions and diamond pastes).

The main parameters that affect the technological process of polycrystalline wafers processing are:

– speed of mutual movement of the grinding abrasive and the wafer;
– value of pressure on the wafer;
– abrasive material;
– the abrasive grains shape;
– bonding material (mineral or organic base);
– grinding material;
– the grinding steps number.

The performed analysis made it possible to determine the dependence of the relief layer and microcracks depths on the size of abrasive grain, which is given in table.1.

Table 1.

Dependence of the relief layer and microcracks depths on the abrasive grain size

Abrasive grain size, [μm]	Relief layer depth, [nm]	Depth of microcracks, [μm]
15	100	1.0-3.0
12	50	1.0
8	10	0.2-0.3
4	< 1	0.1

To improve the wafer surface quality by automating the control operation in the shaping process of polycrystalline semiconductor wafers, a structural diagram of the stages of automated quality control of the wafer during the silicon polycrystals grinding and polishing was developed (Fig.3).

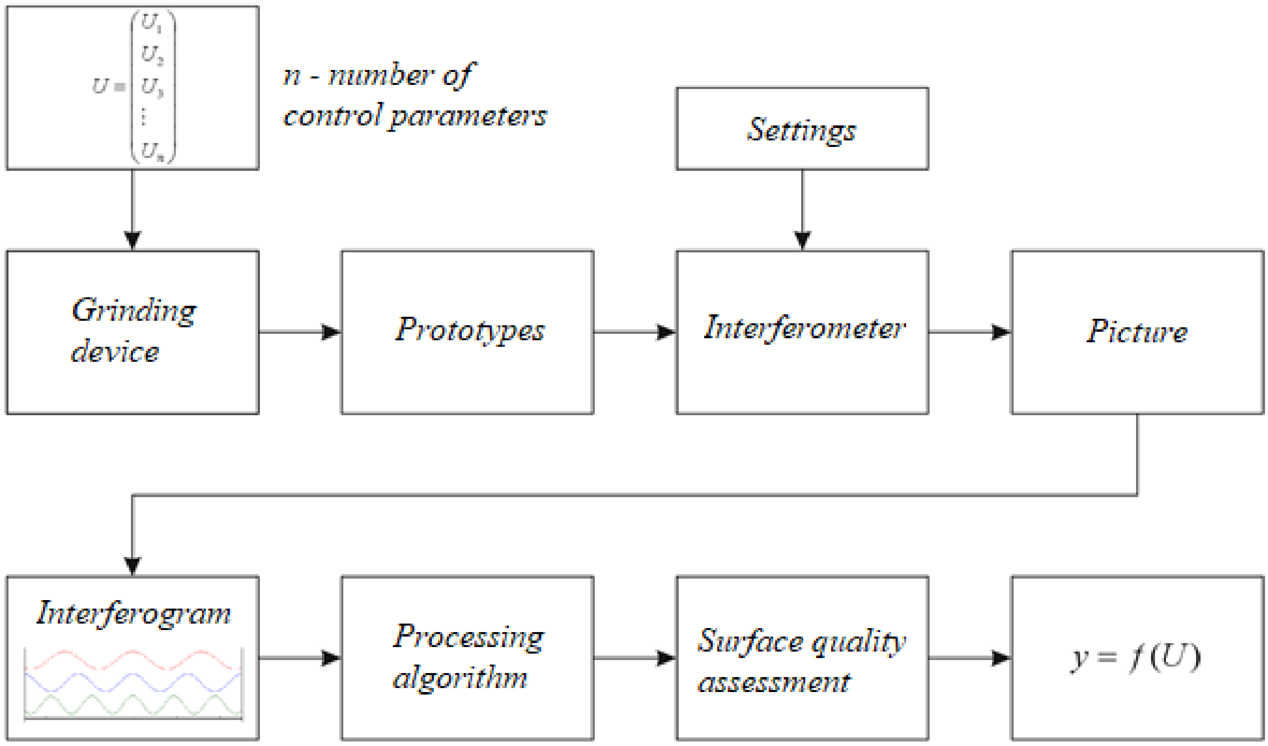

Figure 3. Structural diagram of the stages of polycrystalline silicon wafers surface quality control

Conclusion. The control process automation of the surface quality and silicon polycrystals thickness is of great importance for the entire further technological operations complex of the semiconductor devices or wafers manufacture. In-line control during substrates mechanical processing allows correcting deviations from the norm of the wafers parameters. The developed structural diagram makes it possible to perform the quality control of the semiconductor wafer surface using a modernized interferometer, analyze the obtained data and correct input parameters of grinding operation modes.

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